Final Report, Joint Fire Science Program, RFP 1998

Project Title: A Risk-based Comparison of Potential Fuel Treatment Tradeoff Models

Project Locations: Bitterroot National Forest, MT; Yosemite NP, CA; Angeles National Forest, CA; Gila National Forest, NM; Conecuh National Forest, AL; Blackwater State Forest, FL; Eglin Air Force Base, FL; Huron-Manistee National Forest, MI; Kenai Borough, AK; Beaver County, UT

Project Principal Investigators: David R. Weise (PI); Co-PIs - Michael Arbaugh, J. Greg Jones, Jim Chew, Jim Merzenich, Jan van Wagtendonk, Marc Wiitala, Mark Schaaf, Richard Kimberlin

Contact Information: (951) 680-1543, dweise@fs.fed.us

This final report describes the work accomplished to date and the planned publication and dissemination of results. The data and model parameterizations for the models are included on a CD and are available at several websites.

Project Description: This project was funded in Mar. 1999 with an additional $100,000 added in 2000 to include the Kenai Peninsula in Alaska. The objectives of the project were:

1. To perform a comprehensive sensitivity analysis of SIMPPLLE/MAGIS, VDDT/TELSA and FETM to determine the reliability of each model, and document the justification of the approach used in the internal algorithms.
2. To parameterize FETM, SIMPLLE/MAGIS, and VDDT/TELSA at 8 locations representative of major fuel types found on lands managed by USDA, USDI, DOD, and state agencies. This will include two sites where the models will be implemented with historical information to conduct model validation.
3. Simulate a set of fuel treatments for each model and compare/contrast model results with regard to wildland fire occurrence, smoke emissions and vegetation distribution.
4. Develop methods to use the models to estimate the uncertainty (risk) associated with vegetation changes resulting from fuel treatments in each of the fuel types studied.
5. Develop the data necessary to parameterize the 3 models for a selected site in Alaska.
6. Examine and model fire-size and landscape fragmentation relationship.

Project Deliverables:

Proposed Deliverable	**Actual Accomplishment**
Sensitivity analysis	Sensitivity of model outputs to assumed fire occurrence tested on Angeles National Forest.
FCCs/Model parameterization at 8 locations representing major U.S. fuel types	All 3 models were parameterized for northern Rockies, Sierra Nevada, southern California chaparral, southern Rockies, southern Utah sagebrush and pinyon/juniper, spruce/fir. FETM and VDDT were parameterized for jack pine/mixed hardwoods and longleaf pine/southern hardwoods.
Evaluation of models' ability to reproduce history at 2 locations	Only 1 location, Yosemite National Park, had sufficient historical vegetation and disturbance data to enable us to simulate the period 1937-1997. A current vegetation classification of the Park was not available to compare predictions with current conditions and vegetation classification has changed. We can compare predictions.
Final report including risk analysis, model evaluation and recommended changes	We were unable to get field personnel at the locations who had sufficient time to learning how to use the models in order to assess "user-friendliness" and the processes needed to gather the data in order to use the models. This project also identified that most of the locations did not have the necessary information or information in appropriate form to use in these models. Fire history was lacking in some places and information of plant succession had to be derived from the literature or from knowledgeable experts. Use of all of these models requires specialized training that was not often present in local offices, but resides in regional offices.
GIS-based landscape simulation model designed to implement spatially explicit fire simulation with containment will be developed and validated.	Over the course of this project, significant changes were made to VDDT, SIMPPLLE, and MAGIS to simulate fire spread or occurrence and to model larger areas. We attempted to use TELSA, the spatial version of VDDT, but were unsuccessful because of software and computational requirements. A comparison of predictions from FETM, VDDT, and SIMPPLLE was made with LANDSUM, a model that includes fire spread simulation, on the Bitterroot landscape.

Summary of Findings to Date:

1. The data needed to use these models has limited availability, must be derived from the literature, must be manipulated to be used by the models, and the spatial data often is inconsistent across ownership boundaries.
2. The 3 models were formulated for different purposes, but have been modified to produce similar outputs. Because of the range in complexity of the 3 models, they are perhaps best suited to be used to answer different questions.
3. The skills needed to run MAGIS and SIMPPLLE can likely be run at the district/field or supervisor/district office after they have been parameterized for the general area. However, parameterizing them for the general area requires skills and data that most likely reside at the regional level.
4. The sensitivity of the models to accuracy in the specification of fire return interval is strongly related to the parameterization of the vegetation successional changes.
5. Comparison of outputs is difficult given that the models describe vegetation differently. However, the models in general produce comparable results in a non-spatial sense. SIMPPLLE/MAGIS is the only system that models vegetation distribution and disturbance processes spatially.

Modifications/Enhancement to Models Resulting from Project:

<u>VDDT (Vegetation Dynamics Development Tool)</u>

Software available at http://www.essa.com/downloads/vddt/index.htm

In 1998 VDDT was included in a study to analyze the performance of fuel treatment tradeoff models across all major fuel types within the United States. This study, sponsored by Joint Fire Sciences (JFS) and the Pacific Southwest Research station, provided funding for software enhancements over a 5-year period. As a result, VDDT models are now being used to support fuels and forest planning and are a key component of the *Landfire* fuels mapping process. Significant enhancements to VDDT made as a result of this project follow.

1) The number of potential states (boxes) in a model was increased to 480 and the number of simulation units was increased to 50,000 (previous limits were 60 and 10,000). These changes enable the efficient modeling of entire landscapes.
2) The model can now perform up to 300 simulations in one run and statistically analyze the results of these runs. Previously the model performed only one simulation per run.
3) Disturbance probabilities can now be varied from year to year using a *Variation* section. This enables the modeling of episodic wildfire and insect and disease disturbances. This between-year-variation can either be done randomly based on user defined parameters or can be linked to other factors such as climate or drought cycles.
4) A separate visual basic program is available to generate complex *Monte Carlo multiplier (MCM)* sequences. The program *Build_MCM.exe* enables you to generate multiplier sequences to represent multi-year events such as insect and disease epidemics or cyclic wet and dry periods. The length and periodicity of these events can also be controlled and linked to past events. Program instructions are contained in the VDDT user manual.

5) A *Landscape Condition Feedback* option enables users to link disturbance probabilities to landscape scale conditions. For example you can increase or decrease the level of wildfire in response to average fuel conditions. This feature can also be used to trigger insect outbreaks when risks meet a threshold level.
6) Area limits (e.g. acreage controls) can be applied to any treatment using up to 5 separate time intervals.
7) Attributes that measure the effect of a disturbance or treatment can now be calculated. Examples include smoke emissions and harvest volumes.
8) Trend lines can be applied to disturbance or treatment rates and can vary annually.
9) Disturbance probabilities such as wildfires can be varied based on the time span since a previous disturbance or treatment. This enables one to model the flammable fuels that would result from either the absence of fire or a fuel-reducing disturbance.
10) Users may maintain the relative age when moving simulation units from one state to another. This is helpful when modeling the effect of fuel reduction treatments such as thinning or prescribed fire.
11) Project files, storing the names of files needed to make a VDDT simulation, were developed. This vastly simplifies data management for complex runs.
12) The model can now be run in batch mode. The results of batch runs are written to ASCII text files then imported into databases for interpretation.
13) A set of tutorial exercises was developed, and is now included in the manual, to train users in model basics.
14) Many new graph options have been added to ease the interpretation of model input and output.
15) As a result of this project and the support provided to VDDT development, VDDT models are being developed for all vegetative types in Oregon and Washington and Jim Merzenich is working with the FETM people to build a modeling system that fully integrates FETM and VDDT. VDDT is being used as the primary analysis tool for forest planning in regions 3, 4, and 6. These advances were made possible by the exposure and funding that was provided by this project.

SIMPPLLE (SIMulating Processes and Patterns at Landscape scaLEs)

Software program and landscape data available at
http://www.fs.fed.us/rm/missoula/4151/SIMPPLLE/index.htm

The opportunity to participate in this study has contributed significantly to the continual evolution of the SIMPPLLE modeling system. As we went to each new geographic area the need to be flexible to capture the interaction between fire and other disturbance processes, to capture the relationships at the appropriate scale of spatial relationships, and to capture the significant differences in vegetation communities and ecological stratifications has improved the underlying software design so these types of changes can be easily handled. At the same time the continued improvement in the user interface has resulted in the current version where it is possible for a user to build SIMPPLLE for a new geographic area without the involvement of the model developers (perhaps they will still need some words of advice). Even though the technology transfer phase of the study was never implemented as designed we have still leaned much that contributed to what we wanted to achieve from user feedback.

1) Development of a "zone builder" User can begin to create a new zone through the user interface. Prior to this project the development of a new zone could only be done by the model developers.
2) All system knowledge screens have been expanded to provide not just the capability to edit the probability values, but also the combinations of information (species, size class, density, previous process, previous treatment, spatial relationships) that result in values for the probability of occurrence.
3) Users can completely identify new treatments and build all the feasibility and change logic through the user interface.
4) The fire suppression logic has been expanded to give a user more flexibility to apply different degrees of suppression across the landscape. This can vary from no suppression in wilderness areas to very aggressive suppression in a wildland urban interface.
5) Add the capability to utilize modeling of uniform size plant communities (grids). This makes the system knowledge of spreading insect and fire processes more responsive to the scale of plant community variability. It also facilitates utilization of other analysis tools such as Fragstats to evaluate changes in spatial statistics for wildlife analyses.
6) Expansion of the time step in SIMPPLLE to be a user choice of decade or yearly. The yearly choice provides for capturing a better response between fuel treatments and how long their effectiveness may last. It also provides better interaction between insects and fire processes. A yearly time step provides for better vegetation response for grass and shrub communities that respond to yearly moisture changes. (Regional climate is a variable that is in SIMPPLLE that can change by year).

MAGIS (Multiple-resource Analysis and Geographic Information System**)**

Website: http://www.fs.fed.us/rm/econ/magis/

The following enhancements are presented in chronological order from the beginning of the project.

1) An automated procedure was developed to import into MAGIS the disturbance processes and fuel treatments present on the landscape in the SIMPPLLE simulations of fuel treatment scenarios. This allows us to use MAGIS to compute the combined effects of disturbances and treatments, and compare these effects among the no action and fuel treatment scenarios. Bringing this information into MAGIS to make these computations was logical because MAGIS contains the response relationships for most of these effects.
2) A rule-based process for allocating the logical treatment options to the polygons was implemented in MAGIS, including testing and debugging. This builds the list of candidate treatments from which the MAGIS solver can choose.
3) Various MAGIS screens and processes were converted from FoxPro Ver 2.6 to Visual FoxPro.
4) A process for loading data directly from ArcView has been integrated into MAGIS. This greatly simplifies and streamlines the model-building process. The process for loading MAGIS data from ArcView was modified to create the necessary DLG files from shape files.
5) The model comparisons for JFS involve modeling areas much larger than what MAGIS was originally designed to handle. For example, the Bitterroot Front area contains 9000+ polygons, and the largest area modeled previously contained just under 2000 polygons.

Numerous changes have been made in both the MAGIS code and in the commercial Ketron MPSIII/pc modules used by MAGIS and we can now build and solve models up to 10,000 polygons (although, not all the current map displays work properly for these larger areas). The changes in the MAGIS code include increasing the size of fields in database tables and associated changes in screens and routines that use those tables, changing the formats in all places these database tables either are exported or imported, and modifying several routines to significantly decrease the runtimes needed for these significantly larger problems. Ketron supplied us with new executables for their software that eliminated a limitation on table size that was internal to their programming code. Additional changes in the MAGIS routines will be needed to handle areas having more than 10,000 polygons.

6) We have experimented with the solution parameters used in the MPSIII/pc mixed-integer solver and found a strategy that greatly reduces the solution times needed to achieve feasible solutions that approach the true optimal mixed-integer solutions. This is particularly critical for efficiently solving the larger models we are building for the JFS study.
7) New routines have been developed to more efficiently compute resource effects and output amounts from SIMPPLLE simulations. Being a stochastic model, a number of simulations are made with SIMPPLLE for each management scenario. In the past, a representative simulation from each scenario was selected and exported to MAGIS for the computation of the resource effects and output amounts. Computing these effects for each of the simulations is a more rigorous and reliable method for estimating the expected values for a management scenario. Converting to this approach, however, required a more automated process, as the number of simulations (20 for each management scenario) far exceeded our capability to export these to MAGIS and run each separately. These new routines are the first step in streamlining this process. An additional step has been conceptualized and is needed to make this into the seamless process needed for field applications.
8) MAGIS functional map displays have been upgraded to handle larger areas including: (1) selecting individual decision variables in scenario setup; (2) displaying management regimes and groups of management regimes by period for solutions; and (3) building corridor options in model development. Also upgraded is the routine for building the polygon neighbor file used in adjacency relations.
9) The effort to add activity management relationships to directly tabulate acres treated by specific activities in specific periods was completed. Previously, such tabulations were accomplished by imaginary outputs that equaled one acre of an activity. These activity management relationships will simplify model building, reduce the amount of internal data stored, and reduce the computer times needed for generating a model.
10) The process of moving scenario information from MAGIS to SIMPPLLE was streamlined. This involves converting MAGIS output files into treatment schedule files that are read by SIMPPLLE.
11) Additional protocols have been developed for translating programmed vegetative changes resulting from management activities embedded in the SIMPPLLE program, to the format used in MAGIS, which is a file format listing: Beginning State, Activity, and Resulting State. Protocols were also developed for translating the location of treatments scheduled in a MAGIS scenario to SIMPPLLE. This process became more complicated

when the small, grid-shaped polygons began to be used in the SIMPPLLE simulations, while the MAGIS treatment unit polygons are aggregations of these small "stand" polygons. The small polygons are now being used in SIMPPLLE because they help the modeling disturbance processes that operate at smaller scales. However, treatments are not applied at this small scale, so MAGIS is using larger polygons for scheduling treatments.

12) In cooperation with the Inventory and Monitoring Institute (WO detached unit in Ft. Collins, CO) we developed a scaled-down version of MAGIS, that we call MAGIS eXpress. MAGIS eXpress is much easier for users to apply, while maintaining the critical analytical capabilities of MAGIS. This effort addressed one of the main criticisms we have received, that MAGIS is too complex. Software now available at http://www.fs.fed.us/rm/econ/magis/express1.shtml
13) Developed a wizard in MAGIS for importing data from GIS into the MAGIS data tables.

FETM (Fire Effects Tradeoff Model**)**

Website: http://www.fs.fed.us/r6/aq/fetm/index.htm

A separate Joint Fire Science Program project funded the development and enhancement of FETM.

Increased Model Visibility and Use

As a partial result of funding support from the JFSP and this project, the models received increased visibility and are being more widely used. The funding allowed development of the models (at least SIMPPLLE, MAGIS, and VDDT) by identifying limitations as the models were applied to new areas and vegetation types. For example, SIMPPLLE was modified for shrub systems; it had previously only been used in forests. As a result, they are being more widely used. The fact that the models were part of a large study in a variety of geographic areas leant credibility to the models.

For SIMPPLLE

- The US Fish and Wildlife Service on the Kenai Peninsula wants SIMPPLLE back to help them model "new trajectories for natural fire regimes on the Kenai National Wildlife Refuge in response to global climate change".
- Rocky Mountain National Park, Hawaii Volcanoes National Park and the Big Thicket National Preserve in Texas are interested
- Some very significant work with USGS and Mesa Verde National Park in a project called FRAME (Framing Research for Adaptive Management of Ecosystems) has a pretty high profile in the DOI. We just did an addendum to the Parks Fire Plan on using SIMPPLLE to quantify the impact on fire regimes from the introduction of cheatgrass into the system.
- A consulting firm in Missoula has picked up SIMPPLLE and through contracts with both Timber Industry and environmental groups have been using SIMPPLLE to evaluate Forest Plans in Regions One and Two.

- A nonprofit organization in western Montana paid to develop the grassland components of SIMPPLLE so they could use it in their work with the State of South Dakota in addressing wildlife habitat under historic conditions. We gave them the ability to look at fire interacting with historic bison grazing and prairie dog activity.
- Montana State University is paying to incorporate their research on invasive species probability and spread so people can use SIMPPLLE as the vehicle to deliver their research.
- Northern Arizona University developed an NICCR proposal to use SIMPPLLE in a "Regional Dynamic Vegetation Model for the Colorado Plateau: A Species-Specific Approach" to quantify changes in species distributions as a result of climate changes.
- Birdlife International invited Jim Chew to Poland to make a presentation on SIMPPLLE at a meeting sponsored by them. They are interested in using SIMPPLLE to provide a means to project "Forest Indicators in Europe" that are used as a measure for quantifying biodiversity. They have proposed a pilot study area using a National Park in Poland.

For VDDT

- VDDT models are being developed for all vegetative types in Oregon and Washington
- A modeling system that fully integrates FETM and VDDT is being developed.
- VDDT is being used as the primary analysis tool for forest planning in Forest Service Regions 3, 4, and 6. These advances were made possible by the exposure and funding that was provided by this project.

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